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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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| Applicants: | YONA, Zvi et al. | Examiner: | CHANG, Audrey Y. |
| Serial No.: | 09/818,575 | Group Art Unit: | 2872 |
| Filed: | March 28, 2001 | Attorney Docket No.: | P-3068-US |
| Title: | PERSONAL DISPLAY SYSTEM WITH EXTENDED FIELD OF VIEW | | |

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**Communication Accompanying Corrected Appeal Brief**

Mail Stop **Appeal Brief – Patents**
**Board of Patent Appeals and Interferences**
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Notification of Non-Compliant Appeal Brief mailed by the United States Patent and Trademark Office on June 1, 2007, Applicants submit herewith a corrected Appeal Brief. A response to the Notification of Non-Compliant Appeal Brief is due July 1, 2007; accordingly, the corrected Appeal Brief is being timely field.

No fees are believed to be due in connection with this paper. However, if any fees are in fact due, please charge any such fees to deposit account No. 50-3355.

Respectfully submitted,

Guy Yonay
Attorney for Appellants
Registration No. 52,388

Dated: June 11, 2007

**Pearl Cohen Zedek Latzer, LLP**
1500 Broadway, 12th Floor
New York, New York 10036
Tel: (646) 878-0800
Fax: (646) 878-0801

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# APPEAL BRIEF

Mail Stop **Appeal Brief – Patents**
**Board of Patent Appeals and Interferences**
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

## I. Real Party in Interest

The real party in interest is Elbit Systems Ltd.

## II. Related Appeals and Interferences

There are no related appeals or interferences known to the Appellants.

## III. Status of the Claims

Claims 1-38 have been finally rejected.

Claims 1-38 are appealed.

## IV. Status of Amendments

No amendment has been filed subsequent to the final rejection.

## V. Summary of Claimed Subject Matter

The following is an explanation of the subject matter defined in each of the independent claims involved in this Appeal, followed by an explanation refering to the specification.

**Independent claim 1** recites an apparatus comprising:

an image source to produce along a common optical axis at least first and second complementary images differing in at least one optical property selected from the group consisting of polarization and wavelength;

relay optics having a relay optics field of view associated with said images; and

a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second different, respective, spatial regions of a reflecting unit based on said different optical property, thereby to enable viewing at least said first and second images together by an eye of a viewer as an integrated image having a field of view wider than said relay optics field of view.

**Independent claim 8** recites an apparatus comprising:

an image source to produce along a common optical axis at least first and second complementary images;

relay optics having a relay optics field of view associated with said images; and

a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second different, respective, spatial regions of a reflecting unit, thereby to enable viewing at least said first and second images together by an eye of a viewer as an integrated image having a field of view wider than said relay optics field of view, wherein said redirecting unit comprises a controllable tilting mirror.

**Independent claim 10** recites a helmet comprising:

a reflecting unit with operative connection to said helmet;

an image source to produce along a common optical axis at least first and second complementary images differing in at least one optical property selected from the group consisting of polarization and wavelength;

relay optics having a relay optics field of view associated with said images; and

a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second different, respective, spatial regions of said reflecting unit based on said different optical property, thereby to enable viewing at least said first and second images together by an eye of a viewer as an integrated image having a field of view greater than said relay optics field of view.

**Independent claim 17** recites a helmet comprising:

a reflecting unit with operative connection to said helmet;

an image source to produce along a common optical axis at least first and second complementary images;

relay optics having a relay optics field of view associated with said images; and

a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second different, respective, spatial regions of said reflecting unit, thereby to enable viewing at least said first and second images together by an eye of a viewer as an integrated image having a field of view greater than said relay optics field of view, wherein said redirecting unit comprises a controllable tilting mirror.

**Independent claim 19** recites a method for producing a wide field of view, said method comprising:

producing along a common optical axis at least first and second complementary images differing in at least one optical property selected from the group consisting of polarization and wavelength;

optically transferring said complementary images through relay optics having a relay optics field of view; and

directing at least said first and second images to at least first and second different, respective, spatial regions of a reflecting unit based on said different optical property to enable viewing at least said first and second images together by an eye of a viewer as an integrated image having a field of view wider than said relay optics field of view.

Some embodiments of the invention include an apparatus for increasing the Field Of View (FOV) of an image without substantially increasing the size and the weight of a relay optics of the apparatus. One embodiment of the invention includes an optical system utilizing relay optics and visor, with increased FOV and using a lightweight relay optics. The whole image projected to the viewer 16 is composed of two or more fractions, each of which is relayed utilizing substantially the full FOV of the relay optics. (Specification, page 3, lines 14-20). The apparatus according to embodiments of the invention includes an image source for producing an image, relay optics with a first field of view, for optically transferring a whole image, a redirecting unit for selectively directing fractions of the image at at least two angles and a reflecting unit for reflecting the image fractions to a viewer. The redirecting unit switches between these angles at a speed high enough so that the image fractions received by the viewer are seamlessly integrated into a whole image having wider field of view than the first field of view. (Specification, page 2, lines 7-16).

As illustrated in Figure 2A, image fractions are produced by image source 30, received by relay optics 10, and deviated/reflected at a high speed in at least two directions by image redirector 40. These fractions are then superimposed in visor 15 at appropriate locations to be perceived by the viewer as a seamless

image made up of the fractions of the image. (Specification, page 3, lines 21-25 and page 4, lines 1-4; Figure 2A).

In particular, in the embodiment of the invention illustrated in Figure 2A, the projected image is split into two fractions 101 and 201, with substantially equal angle. The two images, image 101 reflected as image 101' to the left and image 201 reflected as image 201' to the right, one at a time in an alternating rate typically higher than 1 cycle each 25 milliseconds. Both images are reflected from the visor onto the viewer's eyes and received as one by the eye of the user, resulting in a field of view wider than that of each image singly. This allows producing multiple image fractions through one relay optics thus creating an integrated image with FOV substantially wider of the relay optics FOV by the number of the fractions. (Specification, page 4, lines 13-21; Figure 2A).

The movement of the projected fractions of the image on the visor is non-detectable by the eye using a repetition rate of 25 mill-seconds or less. The movement of the deviator/reflector in image redirector 40 is synchronized with the image source so as to allow for the projection of each of the image fractions onto its respectively correct position on the visor 15. (Specification, page 5, lines 8-12).

A time sequential of the operation of the apparatus, when operating as time domain device, i.e., an operation in which the different fractions of the image employ different time slots for projection, is shown in Figure 2B. The top line depicts the selective image fractions produced by image source unit 30, first image 101 and second image 201, and the bottom line depicts the reflective position of the image redirector 40, image 101 to the left and image 201 to the right. Thus, the image source 30 has to be synchronized with the image redirector when operating as a time-domain device. (Specification, page 5, lines 17-24; Figure 2B).

In another embodiment of the invention, as illustrated in Figure 3, the image produced in image source 30 is divided into two complementary frames, 72 with polarization P, and 74 with polarization S. Frame 72 represents the fraction of the

source image that corresponds to the first section on visor 15. Frame 74 represents the fraction of the source image that corresponds to the second section on visor 15. Both frames are projected through an optical combiner 70, and their respective out going optical lines 82 and 84 are projected simultaneously along a common optical axis from the optical combiner 70 through the relay optics 10 and optionally via an Electro Optical (EO) lens 76. When the EO lens 76 is in use, its activity is synchronized with the image source so to allow the free passage of only one of the frames 72 and 74 at once. The outlet image from relay optics 10, whether projected via EO lens 76 or not, is then projected through image redirector 40. (Specification, page 6, lines 3-18; Figure 3).

In yet another embodiment of the invention, as illustrated in Figure 4A, an image redirector 40 is provided, where the reflection angle is controlled in time and may get two or more values. Device 90 is a controllable redirector that may reflect the inbound image in two different angles. Image 72 with polarization P is enabled through EO lens 76, symbolized by arrow 82 representing a midline of the image. Image 72 approaches device 90 that is then controlled into status P so to reflect image 72 along midline 82' onto visor 15, and from visor 15 along mid-line 82" to the viewer 16. The same process takes place with image 74 of polarization S, represented by midlines 84, 84' and 84" respectively. EO lens 76 is synchronized with the activation of device 90. (Specification, page 6, lines 20-26 and page 7, lines 1-5; Figure 4A).

In still another embodiment of the invention, as illustrated in Figure 4B, the image redirector 40 is embodied by an optical device 92, such as a wedge with two polarization-dependent reflective planes. The reflection angle depends only on the polarization of the image, hence two images 72 and 74 are projected continuously onto device 92, and are reflected in different directions (82' and 84') respectively to visor 15, so as to compose a seamless, wide FOV angle, full image of the two polarized fractions of the source image. The FOV angle of the

composed image equals substantially to twice the original FOV angel of the relay optics. (Specification, page 7, lines 7-14; Figure 4B).

In another embodiment of the invention, as illustrated in Figure 5, a visor 15 includes diffractive optics 94 and 96 formed therein. Since the visor 15 is the last optical element before the eye, improving this element (the visor) improves the over-all system performance. Additionally, by adding the diffractive optics to the visor, it is possible to remove some of the optics from within relay optics 10, creating a lighter unit. (Specification, page 8, lines 9-14).

## VI. Grounds of Rejection to be Reviewed on Appeal

The following grounds of rejection are to be reviewed in this Appeal:

A. The Examiner's contention that claims 1-7, 9-16 and 18-38 are unpatentable under 35 USC §112, First Paragraph, as failing to comply with the enablement requirement.

B. The Examiner's contention that claims 1-7, 9-16, 18-23, 35 and 37 are unpatentable under 35 USC §103(a) over United States Patent Number 6,094,283 to Preston ("Preston").

C. The Examiner's contention that claims 34, 36 and 38 are unpatentable under 35 USC §103(a) over Preston in view of United Stated Patent Number 5,198,928 to Chauvin ("Chauvin").

D. The Examiner's contention that claims 8 and 17 are unpatentable under 35 USC §103(a) over United States Patent Number 5,652,666 to Florence et al. ("Florence").

## VII. Argument

### A. Claims 1-7, 9-16 and 18-38 comply with the enablement requirement of 35 USC §112, First Para.

In the Office Action, the Examiner rejected claims 1-7, 9-16 and 18-38 under 35 U.S.C. §112, First Paragraph, as failing to comply with the enablement requirement, on multiple grounds. Applicants below have attempted to parse and respond to each of the Examiner's multiple grounds of rejection.

First, the Examiner related to the feature of "a redirecting unit coupled to said image source to direct . . . to . . . spatial regions of a reflecting unit based on said different optical property", recited in claims 1, 17 and 19, wherein the optical property if polarization or wavelength. The Examiner contended that the specification fails to teach that the reflecting unit is a diffractive optics or a hologram, as recited in claims 2-4, 11-13 and 20-23 when the optical property is polarization. The Examiner contended that a simple reflective unit, such as a mirror, is used in the polarized image light; whereas the diffractive optical element and the hologram disclosed in the present application cannot diffract light based on different polarization state. The Examiner further contended that it is not clear how the reflective unit reflects light based on a different polarization property of the complimentary images.

Appellants respectfully disagree with the Examiner's first Section 112 rejection for the following reasons.

Appellants point to page 8, lines 10-21 of the specification, which discloses:

> Fig. 5 depicts a visor 15 having diffractive optics 94 and 96 formed therein. Since the visor 15 is the last optical element before the eye, improving this element (the visor) improves the over-all system performance. Additionally, by adding the diffractive optics to the visor, it is possible to remove some of the optics from within relay optics 10, creating a lighter unit. . . . Techniques to produce diffractive lens from/on the visor may be: etching, diamond turning, lithography, molding.

Appellants further point to page 9, lines 1-5 of the specification, which discloses:

> Using the same optical relay 10 to achieve a non-distorted wide-FOV imagery, the field correction can be done by reverse-image correction manipulation on the image source such that the projected image to the eye will be non-distorted. Or the correction can be done on the reflected element 15 (visor/combiner) by using a powered reflected optical element such as diffractive, hologram, binary optics.

Accordingly, Appellants respectfully submit that the specification discloses using a reflecting unit, e.g., diffractive optics or hologram, to improve performance and/or efficiency in conjunction with the present invention. This reflecting unit may be used with either the wavelength embodiment or the polarization embodiment, to reflect the projected images to the eye of the user. Methods for optimizing the reflecting unit based on wavelength or polarization are known in the art. Accordingly, Appellants respectfully assert that the specification is enabling and the rejection is traversed.

<u>Second</u>, the Examiner further contended that the specification fails to teach how the redirecting unit could be a polarization selective reflective device that is capable of directing at least said first and second images to at least first and second respective spatial regions of a reflecting unit. The Examiner contended that it is known in the art that a polarization selective reflective device, to the most, can only <u>reflect</u> light with on particular polarization state, but will not be able to <u>redirect</u> light along a common optical axis into different directions (as required by claims 1, 10 and 19), unless a certain specific structure is designed to do so, and that such specific structure is essential to enable the function. The Examiner further contended that the polarization selective reflective device can only reflect "polarized light", whereas no such feature is defined in the claims for the image, and therefore the apparatus is not enabling. The Examiner argued that polarizability alone will not be able to reflect light of different polarization to different spatial regions.

Appellants respectfully disagree with the Examiner's second grounds of rejection under Section 112 for the below reasons.

Appellants point out that the image source produces first and second complementary images differing in at least one optical property, and the redirecting unit directs the first and second images to first and second different, respective, spatial regions of a reflecting unit based on the optical property. Apparently, the Examiner admits that a redirecting unit is disclosed for the wavelength property, and that the redirecting unit is disclosed for the polarization property. The claimed invention does not require that the same redirecting unit be suitable for both wavelength and polarization redirecting, although a redirecting unit may combine the features of both a wavelength and a polarization redirector. Accordingly, the Examiner's rejection is respectfully traversed.

With regard to the Examiner's inquiry how can a redirecting unit be a polarization selective reflective device capable of directing said first and second images to first and second respective spatial regions of a reflecting unit, Appellants submit that such devices are (and were at the time of filing of the present application) well known to those of ordinary skill in the art.

Appellants point to page 7 of the specification, where it is stated that in one embodiment of the invention, "image redirector 40 . . . is embodied by an optical device 92 (such [as] a wedge with two polarization-dependent reflective planes)." Such a wedge having two polarization-dependent reflective planes, each for reflecting light of a different polarization, would operate to direct light polarized differently in different directions.

Appellants respectfully submit that the practical and theoretical bases for such an element described in the embodiment are well known in the art. For example, Appellants has attached to a previous response to Office Action (filed on August 16, 2004), and further enclose herein as <u>Appendix A</u>, pages 331-335 of a 1965 Edition of the book "Applied Optics and Optical Engineering", by Rudolf

Kingslake. In Appendix A, polarization by double refraction is described, for example by use of a Rochon or Wollaston prism.

Appellants further submit that other suitable devices are known in the art for such purposes and are commercially available. For example, Appellants have attached to a previous response to Office Action (filed August 16, 2004), and further enclose herein as Appendix B, pages 234-235 of a 1998-99 catalog for laser and photonics applications from Coherent, which offers for sale polarizing beamsplitting cubes and prisms. As explained therein, the effect of such devices is to receive an incoming beam and divide it into its component polarized components. Any of these devices is able to take a beam of a first polarization and direct it in a first direction and direct a second beam of a second polarization in a second direction.

Appellants point out that in the Final Office Action (bottom of page 3, top of page 4), apparently the Examiner admits that the "wedge with two polarization-dependent reflective planes", as disclosed in the specification, indeed enable the apparatus.

Third, the Examiner contended that the "wedge with two polarization-dependent reflective planes", which is disclosed in the specification, is essential structure for making the apparatus operable, but is not explicitly recited in the rejected claims.

With this third ground for rejection, too, Appellants respectfully disagree.

The "wedge with two polarization-dependent reflective planes", which is disclosed in the specification, indeed enables the apparatus; however, the wedge is only an exemplary implementation of many structures and devices known in the art to both reflect and redirect light. Such structures and devices are known in the art, as reflected, for example, in Appendix A and Appendix B. Therefore, Appellants respectfully submit that the "wedge with two polarization-dependent

reflective planes", while enabling the apparatus, is not an essential structure of the claimed invention and need not be recited in the rejected claims.

Fourth, with regard to claims 34 and 36, the Examiner inquired how an image source can be capable of generating spatially complementary images of different wavelengths or of different polarizations. The Examiner contended that multiple different image generators are required for generating different images of different wavelengths or of different polarizations.

Appellants respectfully disagree. Appellants point to page 7 of the specification, which discloses that in one embodiment of the invention, the image source may be "one common display (such as with a LCD display). The image source may be any type of display technology using P&S polarizers or LCD technology (such as from: Sony, Sharp, Kopin, MicroDisplay and others). . ."

It is well known in the art that a Liquid Crystal Display (LCD) polarizes an incoming light beam by 90 degrees. Accordingly, allowing a polarized image to pass the LCD without electro-optic modulation would produce an image having a first polarization. Alternatively, taking the polarized image and electro-optically modulating it would produce an image having a second polarization orthogonal to the first.

Fifth, with respect to the Examiner's inquiry regarding producing images having different wavelengths, it is also known in the art that an LCD can produce multiple colors, e.g., as displayed on laptop computers having a color LCD screen. Accordingly, in one embodiment of the invention, by using the same LCD image source to produce different colored images in time sequence, different wavelength images may be formed.

Sixth, the Examiner further inquired how the wavelength sensitive redirecting unit can be capable of directing first and second complementary images to different spatial locations according to wavelength, and required

clarifications. The Examiner contended that a wavelength sensitive device cannot redirect the image light to different directions or locations.

Appellants respectfully submit that it is well know in the art that wavelength sensitive units are capable of redirecting first and second complementary images to different spatial locations according to wavelength. For example, a prism does precisely this – direct beams of light having different wavelengths to different spatial locations. Hence, when white light enters a prism, the component colors (wavelengths) emerge at different angles to different spatial locations.

In view of the above, Appellants respectfully submit that claims 1-7, 9-16 and 18-38 comply with the enablement requirement under 35 USC §112, First Paragraph.

**2. Claims 1-7, 9-16, 18-23, 35 and 37 are patentable <u>under 35 USC §103(a) over Preston</u>**

In the Office Action, the Examiner rejected claims 1-7, 9-16, 18-23, 35 and 37 under 35 U.S.C. § 03(a), as being unpatentable over Preston.

Appellants respectfully assert that Preston does not render claims 1-7, 9-16, 18-23, 35 and 37 obvious because Preston does not disclose, teach or suggest every element of the these claims.

Preston describes "A holographic display system comprising left and right optical systems . . . The optical systems each comprise an image display operable to display an input image and first and second holographic devices." (Abstract).

In the device according to Preston, each of the image display units takes a single image and decomposes it into its RGB components and transmits each of these separately to the same area of the eye piece 38, thereby recreating the single image. Thus, each of the left and right input image displays 40 projects <u>only one image</u> on its respective portion of the reflective eye piece 38. That is, the <u>left</u> input image display projects a <u>first</u> image on the <u>left</u> side of the eye piece 38 to be

viewed by the left eye, and the right input image display projects a second image on the right side of the eye piece 38 to be viewed by the right eye. This is clearly seen in the series of figures including Figures 2A and 2B. Finally, these two images, produced by two different input image displays on separate portions of the eye piece to be viewed by different eyes do not physically overlap on the eye piece.

The Examiner contended that in each side of the eye piece, the color components of each image are "first and second complementary images differing in wavelength." These, however, are not first and second complementary images, as recited in independent claims 1 and 10, but rather first and second color components of the same image.

Moreover, because each input image display 40 displays a single image in its color components, and not two different images (as recited in independent claims 1 and 10), this same single image of Preston is reconstructed at the same area of the eye piece 38 (see Preston's Figure 1). Preston therefore does not teach directing "first and second images to at least first and second, respective, spatial regions of a reflecting unit based on said different optical property." Preston, at most, describes directing the first and second color components of the same image to the same area of the eye piece, thereby producing a single image at one location.

As an aside, Appellants respectfully disagree with the Examiner's assertion regarding Preston's the field of view. While it may be true that the overall image seen by the viewer in Preston is wider than that of each of the relay optics, this widening is not performed by one relay optic, but by the combination of two relay optics.

Therefore, the Preston reference does not render obvious independent claims 1 and 10 because Preston does not teach or suggest neither (a) an image source to produce along a common optical axis at least first and second

complementary images, nor (b) a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second, respective, spatial regions of a reflecting unit.

Likewise, with respect to independent claim 19, the method of operation of Preston does not teach or suggest "producing along a common optical axis at least first and second complementary images" nor "directing at least said first and second images to at least first and second, respective, spatial regions of a reflecting unit."

In view of the above, dependent claims 1, 10 and 19 of the Application are not rendered obvious by Preston, either alone or in combination with any other art of record.

Claims 2-7, 9, 11-16, 18, 20-23, 35 and 37, which depend from independent claims 1, 10 and 19, are likewise not rendered obvious in view of Preston and/or the art of record.

Accordingly, Appellants respectfully submit that claims 1-7, 9-16, 18-23, 35 and 37 are patentable under 35 USC §103(a) over Preston.

**3. Claims 34, 36 and 38 are patentable**
**<u>under 35 USC §103(a) over Preston in view of Chauvin</u>**

In the Office Action, the Examiner rejected claims 34, 36 and 38 under 35 U.S.C. §103(a), as being unpatentable over Preston as applied to claims 1, 10 and 19 above, and further in view of Chauvin.

In Chauvin, "[a] binocular, stereoscopic helmet visor display is described, wherein a polarization x-prism is used to separate the left eye imagery from the right eye imagery when each channel has a unique polarization. <u>Separate image sources generate the left and right eye imagery</u>, and the respective left and right image light is passed through polarizers so that the respective left and right image light is of opposite polarizations." (Abstract, emphasis added).

As discussed with respect to Preston, above, Chauvin does not teach or suggest (a) an image source to produce along a common optical axis at least first and second complementary images, and/or (b) a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second, respective, spatial regions of a reflecting unit, as recited in claims 1, 10 and 19, from which claims 34, 36 and 38 respectively depend indirectly.

Therefore, claims 34, 36 and 38 are not rendered obvious in light of Preston in view of Chauvin.

**4. Claims 8 and 17 are patentable <u>under 35 USC §103(a) over Florence</u>**

In the Office Action, the Examiner rejected claims 8 and 17 under 35 U.S.C. §103(a), as being unpatentable over Florence.

The Examiner contended that Florence describes all the features of claims 8 and 17, with the exception that Florence does not disclose use of a reflecting unit as the means for forming the integrated image; however, the Examiner argued that using a reflecting unit as the means for forming the integrated image as claimed would have been obvious to one skilled in the art.

Appellants respectfully traverse the rejection of claims 8 and 17 based on Florence because a *prima facie* case of obviousness has not been established. Florence does not disclose, teach or suggest all of the features of claims 8 and 17 of the present Application.

Florence describes a "method of using a display system having a spatial light modulator (14) to display holographic images. The spatial light modulator (14) generates images that represent vertical strips of a hologram. These images are de-magnified by a three-dimensional optics unit (18), in the horizontal direction so as to form image strips. A scanning mirror (45) scans the image strips in a

series across an image plane at a rate sufficiently fast that the viewer perceives a composite hologram comprised of these image strips." (Abstract).

In particular, Florence describes a digital micro-mirror device (DMD) 14 (or other spatial light modulator (SLM)) to produce a single image. This entire single image is then relayed continuously, vertical strip by vertical strip, using relay optics 41-43 and a scanning mirror 45, and then to an image plane 46. (Florence, column 5, lines 3-13; Figure 4). Thus, in Florence, an entire image is produced by an image source, but only portions of the image are viewed at the image plane in a scanning action.

Florence does not render obvious any of claims 8 and 17 because Florence does not disclose, teach or suggest at least "an image source <u>to produce along a common optical axis</u> at least first and second complementary images", as recited in claims 8 and 17.

Appellants submit that to the extent that the vertical strips of Florence may be called first and second complementary images, the vertical strips of Florence are not produced along a common optical axis, but rather, along adjacent but separate optical axes. Nor would producing the different vertical strips along a common optical axis have been obvious in light of Florence.

Therefore, claims 8 and 17 are not rendered obvious in view of Florence.

## VIII. Claims Appendix

1. Apparatus comprising:
an image source to produce along a common optical axis at least first and second complementary images differing in at least one optical property selected from the group consisting of polarization and wavelength;
relay optics having a relay optics field of view associated with said images; and
a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second different, respective, spatial regions of a reflecting unit based on said different optical property, thereby to enable viewing at least said first and second images together by an eye of a viewer as an integrated image having a field of view wider than said relay optics field of view.

2. The apparatus of claim 1, wherein said reflecting unit comprises diffractive optics formed therein.

3. The apparatus of claim 2 wherein said diffractive optics comprises binary optics.

4. The apparatus of claim 1 wherein said reflecting unit comprises diffractive optics on its inner and outer faces so to create a total zero optical power for the outer scene.

5. The apparatus of claim 1 wherein the number of said images is at least two.

6. The apparatus of claim 1, wherein said images are of different wavelength.

7. The apparatus of claim 1, wherein said images are of different polarization.

8. Apparatus comprising:
an image source to produce along a common optical axis at least first and second complementary images;
relay optics having a relay optics field of view associated with said images; and
a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second different, respective, spatial regions of a reflecting unit, thereby to enable viewing at least said first and second images together by an eye of a viewer as an integrated image having a field of view wider than said relay optics field of view,
wherein said redirecting unit comprises a controllable tilting mirror.

9. The apparatus of claim 7, wherein said redirecting unit comprises a polarization selective reflecting device.

10. A helmet comprising:
a reflecting unit with operative connection to said helmet;
an image source to produce along a common optical axis at least first and second complementary images differing in at least one optical property selected from the group consisting of polarization and wavelength;
relay optics having a relay optics field of view associated with said images; and
a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second different, respective, spatial regions of said reflecting unit based on said different optical property, thereby to enable viewing at least said first and second images together by an eye of

a viewer as an integrated image having a field of view greater than said relay optics field of view.

11. The helmet of claim 10, wherein said reflecting unit comprises diffractive optics formed therein.

12. The helmet of claim 11, wherein said diffractive optics comprises binary optics.

13. The helmet of claim 10 wherein said reflecting unit comprises diffractive optics on its outer faces so to create a total zero optical power for the outer scene.

14. The helmet of claim 10, wherein the number of said images is at least two.

15. The helmet of claim 10, wherein said images are of different wavelength.

16. The helmet of claim 10, wherein said images are of different polarization.

17. A helmet comprising:
a reflecting unit with operative connection to said helmet;
an image source to produce along a common optical axis at least first and second complementary images;
relay optics having a relay optics field of view associated with said images; and
a redirecting unit coupled to said image source to direct at least said first and second images to at least first and second different, respective, spatial regions of said reflecting unit, thereby to enable viewing at least said first and

second images together by an eye of a viewer as an integrated image having a field of view greater than said relay optics field of view,
wherein said redirecting unit comprises a controllable tilting mirror.

18. The helmet of claim 16, wherein said redirecting unit comprises a polarization selective reflecting device.

19. A method for producing a wide field of view, said method comprising:
producing along a common optical axis at least first and second complementary images differing in at least one optical property selected from the group consisting of polarization and wavelength;
optically transferring said complementary images through relay optics having a relay optics field of view; and
directing at least said first and second images to at least first and second different, respective, spatial regions of a reflecting unit based on said different optical property to enable viewing at least said first and second images together by an eye of a viewer as an integrated image having a field of view wider than said relay optics field of view.

20. The apparatus of claim 2 wherein said diffractive optics comprises holograms.

21. The apparatus of claim 2 wherein said diffractive optics comprises optic-powered implemented optics.

22. The helmet of claim 11 wherein said diffractive optics comprises holograms.

23. The helmet of claim 11 wherein said diffractive optics comprises optic-powered implemented optics.

24. The apparatus of claim 6, wherein said redirecting unit comprises a wavelength selective reflecting device.

25. The apparatus of claim 1 wherein said first and second different respective spatial regions of said reflecting unit are adjacent to each other.

26. The apparatus of claim 1 wherein said image source is able to sequentially produce said first and second complementary images.

27. The helmet of claim 15, wherein said redirecting unit comprises a wavelength sensitive reflecting device.

28. The helmet of claim 10 wherein said first and second different respective spatial regions of said reflecting unit are adjacent to each other.

29. The helmet of claim 10 wherein said image source is able to sequentially produce said at least first and second complementary images.

30. The method of claim 19, wherein directing said images to said spatial regions of the reflecting unit comprises directing said images to said spatial regions of the reflecting unit based on polarization of said images.

31. The method of claim 19, wherein directing said images to said spatial regions of the reflecting unit comprises directing said images to said spatial regions of the reflecting unit based on wavelength of said images.

32. The method of claim 19 comprising sequentially producing said at least first and second complementary images.

33. The apparatus of claim 1, wherein said image source is adapted to simultaneously produce said first and second complementary images.

34. The apparatus of claim 33, wherein said image source comprises at least first and second image generating devices to produce said first and second complementary images and a combiner to combine onto said common optical axis said first and second complementary images.

35. The helmet of claim 10, wherein said image source is adapted to simultaneously produce first and second complementary images.

36. The helmet of claim 35, wherein said image source comprises at least first and second image generating devices to generate said first and second complementary images and a combiner to combine onto said common optical axis said first and second complementary images.

37. The method of claim 19, wherein said producing comprises simultaneously producing said first and second complementary images.

38. The method of claim 37, wherein said simultaneously producing said first and second complementary images comprises:
generating said first and second complementary images; and
combining said first and second complementary images onto said common optical axis.

## IX. Evidence Appendix

Appellants submit herewith:

Appendix A, including pages 331-335 of a 1965 Edition of the book "Applied Optics and Optical Engineering", by Rudolf Kingslake, which Appellants has attached to a previous response to Office Action filed on August 16, 2004; and

Appendix B, including pages 234-235 of a 1998-99 catalog for laser and photonics applications from Coherent, which Appellants has attached to a previous response to Office Action filed on August 16, 2004.

## X. Related Proceedings Appendix

There are no related proceedings known to the Appellants.

## Conclusion

In view of the foregoing arguments, and for at least the reasons discussed above, Appellants respectfully submit that the final rejection should be reversed and claims 1-38 should be allowed.

No fees are believed to be due in connection with this paper. However, if any fees are due, please charge any such fees to deposit account No. 50-3355.

Respectfully submitted,

Guy Yonay
Attorney for Appellants
Registration No. 52,388

Dated: June 11, 2007

**Pearl Cohen Zedek Latzer, LLP**
1500 Broadway, 12th Floor
New York, New York 10036
Tel: (646) 878-0800
Fax: (646) 878-0801

# APPENDIX A

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# APPLIED OPTICS and OPTICAL ENGINEERING



EDITED BY
RUDOLF KINGSLAKE
*Eastman Kodak Company*
*Rochester, New York*

## VOLUME I

## Light: Its Generation and Modification

ACADEMIC PRESS New York San Francisco London 1965
*A Subsidiary of Harcourt Brace Jovanovich, Publishers*

ACADEMIC PRESS INC.
111 Fifth Avenue, New York, New York 10003

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24/28 Oval Road, London NW1

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PHILIP T. SCHARF, *E*

HAROLD S. STEWART,

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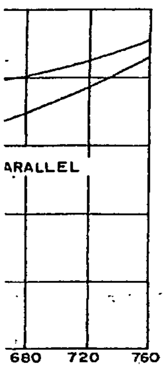


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angle. In some rotating-polarizer modulator arrangements this inhomogeneity can cause "subharmonic" distortion, the areas of maximum density not being 180° apart. The best cure is to use small areas of the sheet and to use the same areas during a complete cycle.

A different form of polarizer is the metallic polarizer. In these sheet polarizers, small needles of metal are oriented parallel to one another. This polarizer works because the absorption of light by the lattice of needles depends on the direction of the electrical vector with respect to the needle axis. One of Hertz' numerous experiments with electromagnetic waves showed that a grating formed of parallel wires is almost opaque to electromagnetic waves when the electrical vector is parallel to the plane of polarization and almost transparent when the electrical vector is perpendicular to them. Hertz' results were extended to the far infrared by DuBois and Rubens.

The mechanical problems of making near-infrared or visible polarizers in this manner are quite formidable. However, a method originated by Bird and Parrish[6] has solved this problem. They have vacuum shadow-cast, with gold or aluminum, the steep face of transmission echelette grating replicas. These replicas, made of polyethylene or polyfluorocarbon, thus have a series of parallel wires on them made of the shadow-cast metal. At wavelengths larger than 4 to 8 times the spacing of the grating, polarization is reasonably complete, and successful polarizers have been made in this manner. Since the untransmitted portion is reflected, the possibility of a sheet polarizing beam splitter exists.

### C. Polarization by Double Refraction

Transparent substances fall into two main categories:

(1) Isotropic media in which the velocity of transmission, i.e. the refractive index, is independent of the plane of polarization.

(2) Anisotropic media in which the refractive index in general does depend on the plane of polarization. Anisotropic media are said to be birefringent.

Isotropic media include gases, unstrained noncrystalline solids, liquids, and crystals of the cubic system. Anisotropic media include crystals of the tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic systems, and strained materials.

In general, a beam of light transmitted through an anisotropic crystal is doubly refracted. The beam is divided into two beams, each of which is plane polarized at right angles to the other. Figure 2 illustrates how this occurs.

[6] G. R. Bird and M. Parrish, Jr., *J. Opt. Soc. Am.* 50, 886 (1960).

In such anisotropic media there are one or two directions in which light is transmitted without double refraction. A material for which there is one such direction is said to be uniaxial. Such materials are tetragonal or hexagonal crystals. Materials for which there are two directions in which no double refraction takes place are said to be biaxial. The direction, or directions, in which no double refraction takes place is called the optic axis, and it should be emphasized that the optic axis is not a line but a direction.

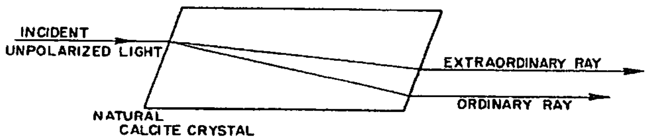


FIG. 2. Double refraction through an anisotropic crystal.

For one of the rays into which a light beam is divided in anisotropic media, Snell's law of refraction is obeyed. This ray is called the ordinary ray. For the other ray Snell's law is not obeyed and the ray is therefore called the extraordinary ray. The extraordinary ray may have a refractive index either higher or lower than that of the ordinary ray.

That the refractive index of an anisotropic material depends on the plane of polarization of the light provides a way of isolating one polarization from another in incident unpolarized light. We may take advantage of the polarization-dependent dispersion of naturally occurring anisotropic media to get polarized light.

The classical way of performing the isolation of one plane of polarization uses an optical device made from a calcite crystal, the Nicol prism, illustrated in Fig. 3. The refractive indices for sodium light of the ordinary ray in calcite, the extraordinary ray, and the balsam cement are, respectively, 1.6585, 1.4864, and 1.54.

The cement, we see, has a refractive index between that of the ordinary ray and that of the extraordinary ray. The extraordinary ray will be refracted at the balsam cement layer and will pass from there on through the crystal. However, the ordinary ray, over an appreciable angular range, will be totally reflected out of the direct beam. The critical angle for total reflection of the ordinary ray corresponds to an angle of about 15° outside the prism. This means that the Nicol prism is not effective as a polarizer in highly convergent or divergent light.

The extraordinary ray also has an angular limit, and beyond this limit the extraordinary ray is also totally reflected. This arises because the refractive index of calcite varies with direction. At some angle the balsam

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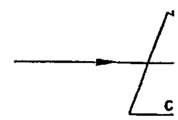

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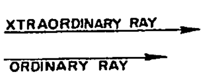


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will have a lower refractive index than that of the extraordinary ray. The prism is cut so that the external limiting angle for the extraordinary ray is the same as the external limiting angle for the ordinary ray, about 15°. The direction of incident light on a Nicol prism is therefore limited on one side to avoid transmitting the ordinary ray, and on the other side to avoid having the extraordinary ray totally reflected.

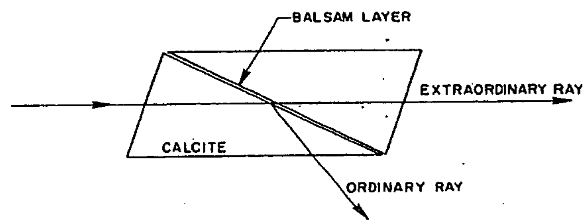


FIG. 3. The Nicol prism.

For separating two mutually perpendicular polarizations rather than for removing one of them, two other prisms are useful. These are the Rochon prism and the Wollaston prism (Fig. 4). With the Rochon prism, the ordinary ray is undeviated while the extraordinary ray is deviated; with the Wollaston prism both rays are deviated.

Prisms of different design from the Nicol are used in different applications. Some are more economical of material by virtue of being more suitable to the shape of naturally occurring crystals of calcite. Some have a wider permissible field angle. Other designs have faces which are perpendicular to the direction of the light and hence are usable in nonparallel light. Still others are suitable for use in the ultraviolet because they contain either no cement or a cement transparent in the ultraviolet.[7–9]

Another kind of construction uses a doubly refracting plate immersed in a suitable liquid. The arrangement is to have the lower index of the crystal lower than the index of the liquid and to mount the crystal at such an angle that the light of the unwanted polarization is critically reflected out of the path. Such an immersed arrangement is fragile but has usefulness because it is conservative of material. It is also useful in the ultraviolet because the amount of absorbing, double-refracting, material in the optical path is reduced. The crystal material used in the ultraviolet is ammonium dihydrogen phosphate.

[7] L. C. Martin, "Introduction to Applied Optics," Vol. I. Pitman, New York, 1930.
[8] R. W. Wood, "Physical Optics," 3rd ed. Macmillan, New York, 1930.
[9] S. P. Thompson, *Proc. Opt. Conv., London, 1905*, p 216 (1905).

Yet another form of birefringent polarizer uses small crystals of birefringent material, the size of the crystals being several times the wavelength. The crystals are suspended in a plastic matrix which has a refractive index equal to one of the principal indices of the birefringent crystals. The sheet is then stretched so that all of the birefringent crystal axes are aligned. The resultant sheet is transparent for one

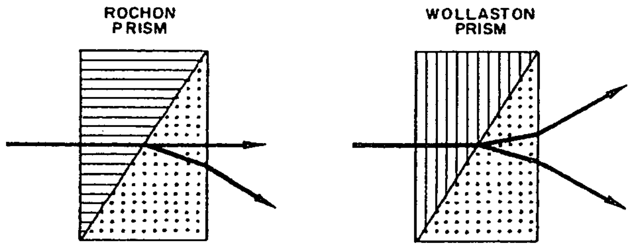


FIG. 4. The Rochon and Wollaston prisms.

orientation of the analyzer, but when the sheet is turned 90° it becomes turbid and highly diffusing. The material acts like a variable diffuser, a diffuser with variable forward gain.

## D. Polarization by Scattering

When a beam of light is passed through a suspension of small particles, the light will be scattered by the particles. If the particles are very much smaller than the wavelength of the light, the scattered light will be plane polarized with the plane of polarization being perpendicular to the plane defined by the direction of propagation and the line of sight. If the incident light is plane polarized then no light is scattered parallel to the plane of polarization.

For particles very much smaller than the wavelength, the polarization is complete at right angles to the direction of propagation, and the degree of polarization is given by $P = \sin^2\theta/(1+\cos^2\theta)$. Here $\theta$ is zero when the source is observed directly and 180° when the observer is at the source. As the size of the particles increases, the direction of maximum polarization generally shifts toward 180° for transparent spheres and toward 0° for absorbing spheres. However, for larger particles the behavior is irregular and exact application of the theory is required for prediction.[10]

[10] H. C. Van de Hulst, "Light Scattering by Small Particles." Wiley, New York, 1957.

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[12] R. Ribbands, *Sci.*
[13] P. Drude, "The T
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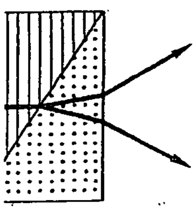

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For different wavelengths, polarization maxima occur at different angles. When scattered light is observed through a polarizer, complicated color phenomena called "polychromism" may be seen. The scattering of light may also be attributed to small density fluctuations in gases and liquids, or to the optical anisotropy of solids.[11]

The scattering of sunlight by the molecules of the air gives rise to the polarization of the light from the sky. The polarization maximum is 90° away from the direction of the sun, and so was proposed by A. J. Pfund as a navigation instrument particularly suited to the long twilights of the polar regions. The invention was anticipated and reduced to practice by the bees, who have been shown to use the phenomenon for navigation.[12]

## E. Polarization by Emission

### 1. *The Polarization of Light Emitted by Continuous Radiators*

By Kirchhoff's laws the emissivity of a body is equal to its absorptivity for any wavelength for any angle of incidence, and for any azimuth of polarization. At other than normal incidence, the reflectance, and hence the absorptivity, of a body depends on the azimuth of polarization of the incident radiation (Section X). It is not surprising, therefore, that the light emitted by a hot body at oblique angles is partially polarized.

For naturally pleochroic substances like tourmaline (Section II, B), the absorptivity depends on the azimuth of polarization of the incident light even at normal incidence. To the extent that tourmaline retains this property at incandescence, it does indeed radiate polarized light when viewed perpendicularly.[13]

### 2. *The Polarization of Light Emitted as Čerenkov Radiation*

When electrons move through a medium having a refractive index $n$ with a velocity greater than $c/n$, one observes Čerenkov radiation. This radiation propagates within a cone whose axis is the direction of electron motion. The electrical vector of this radiation lies in the plane defined by the direction of electron motion and the direction of propagation of the radiation.

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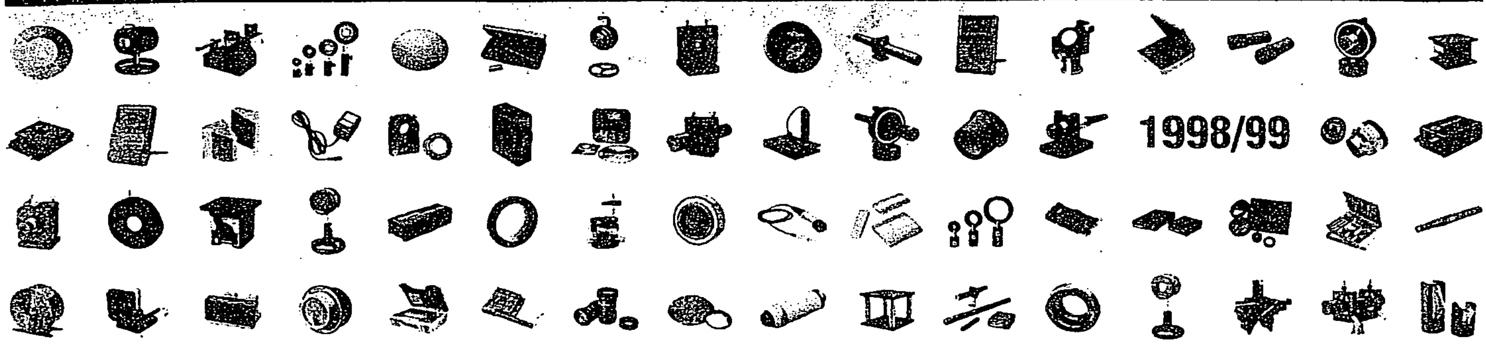
[11] S. Bhagavantom, "Scattering of Light and the Raman Effect." Chem. Publ. Co., New York, 1942.
[12] R. Ribbands, *Sci. Am.* **193**, 52 (1955).
[13] P. Drude, "The Theory of Optics" (transl. by C. R. Mann and R. A. Millikan), p. 501. Longmans, Green, New York, 1933; also Dover, New York, 1959.

# APPENDIX B



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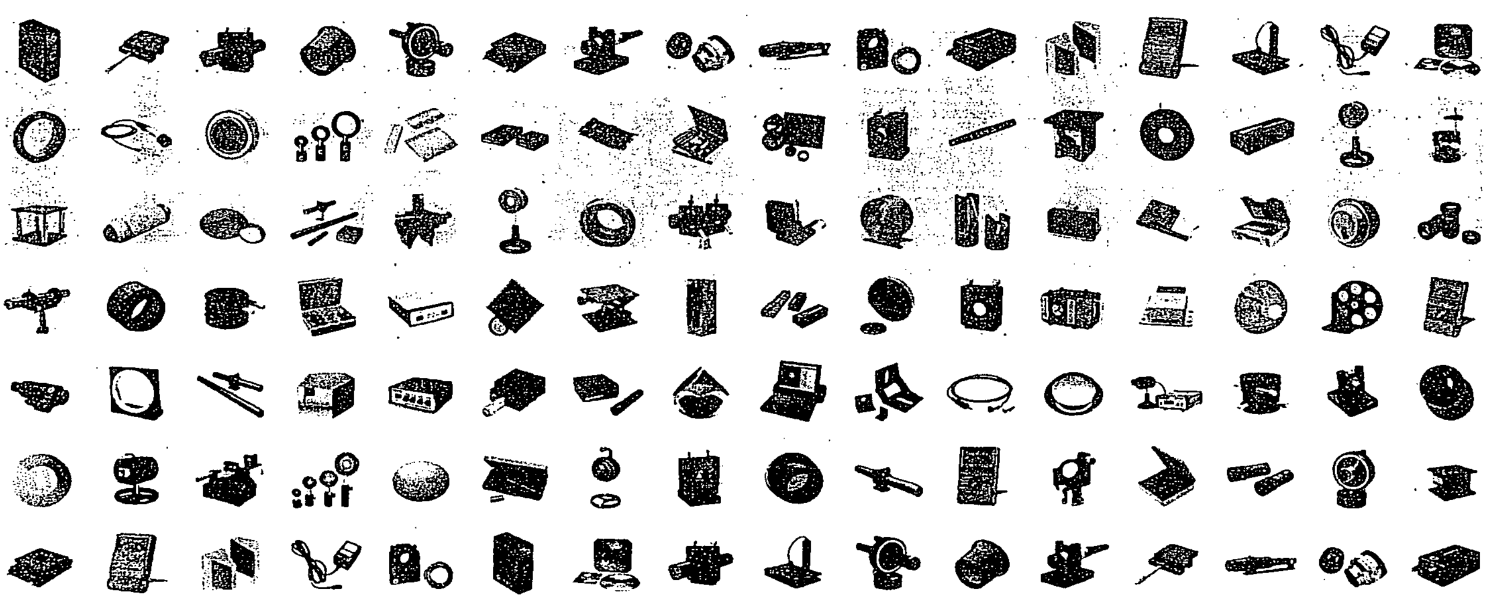
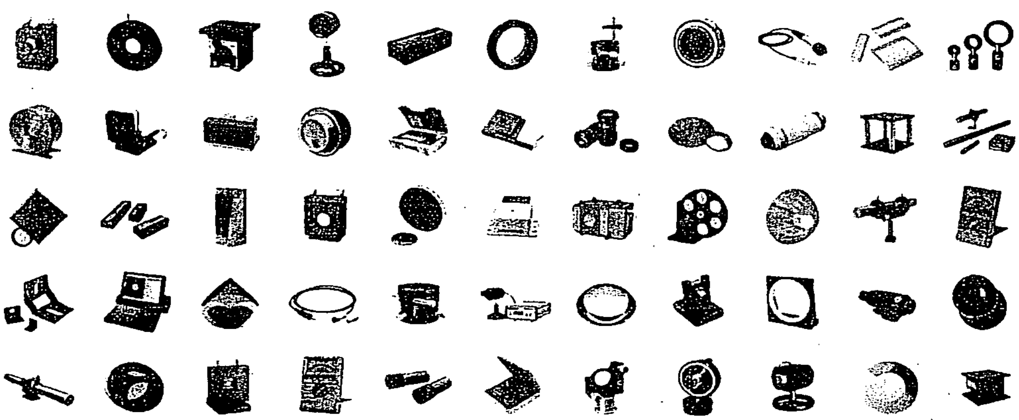
## The Catalog for Laser and Photonics Applications





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**Optics**

**Opto-mechanics**

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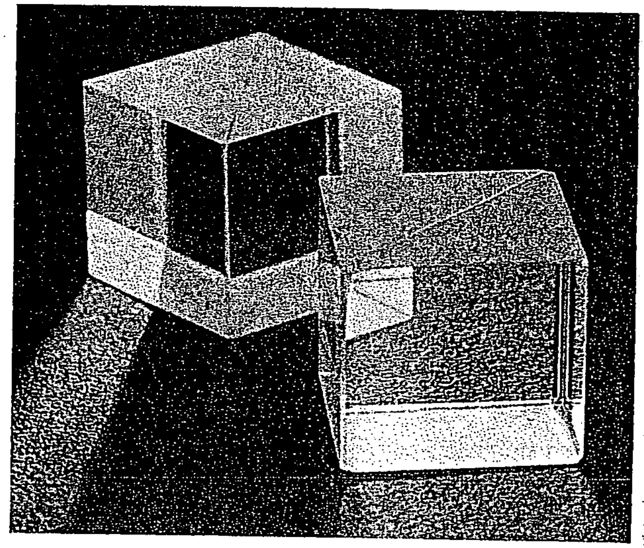
AUBURN GROUP

# Polarizing Beamsplitter Cubes

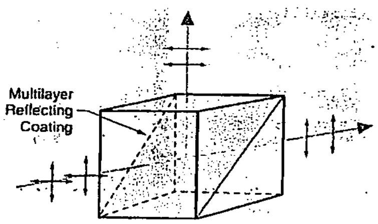
- ***Rugged and convenient polarizers***
- ***Common laser wavelengths***

Polarizing Beamsplitter Cubes split randomly-polarized beams into two beams - one is transmitted straight through and the other is reflected internally and emerges from another face of the cube. The hypotenuse face of one of the prism is coated with a multilayer dielectric coating, such that the reflection from each layer is partially polarized and the cumulative effect of the multilayer coating produces a transmitted and reflected beam both of which are highly polarized with the transmitted beam being p-polarized and the reflected beam s-polarized. Two prisms are bonded together with index-matching cement. The entrance and exit faces are antireflection coated.



## *Narrow Band Polarizing Beamsplitter Cubes*

Narrow Band Polarizing Beamsplitter Cubes are cemented components that are optimized for specific wavelengths. They are the best choice for use with single line cw lasers, attenuators, beam combining and clean-up. The angle between the transmitted and reflected beam is 90°.




**Narrow Band Polarizing Beamsplitter Cubes**

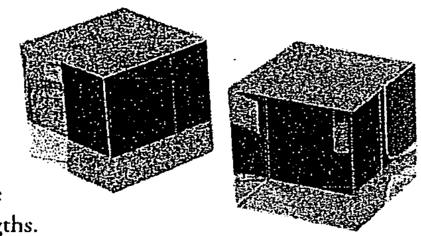
| Wavelength (nm) | 12.7 mm Cube Catalog Number | 25.4 mm Cube Catalog Number |
|---|---|---|
| 488 | 44-4380 | 44-4398 |
| 514 | 44-4406 | 44-4414 |
| 532 | 44-4422 | 44-4430 |
| 633 | 44-4448 | 44-4455 |
| 650 | 44-4463 | 44-4471 |
| 670 | 44-4489 | 44-4497 |
| 780 | 44-4505 | 44-4513 |
| 808 | 44-4521 | 44-4539 |
| 830 | 44-4547 | 44-4554 |
| 850 | 44-4562 | 44-4570 |
| 1064 | 44-4588 | 44-4596 |
| 1300 | 44-4604 | 44-4612 |
| 1550 | 44-4620 | 44-4638 |

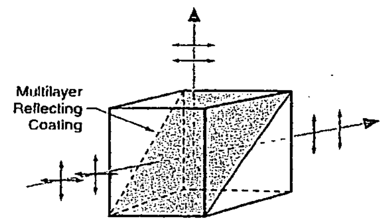
### Specifications

**Material:** BK7 glass
**Transmission (p-polarized):** >95%
**Reflection (s-polarized):** >99.8%
**AR Coating:** R ≤0.25% per surface
**Typical Polarizing Bandwidth:** 10 nm
**Transmitted Wavefront:** λ/4 at 633nm
**Surface Quality:** 20-10
**Extinction Ratio:** 1000:1
**Dimensions:** ±0.2 mm
**Clear Aperture:** 80% of cube dimension
**Laser Damage Threshold**
CW: 2 kW/cm²
Pulsed (10 ns): 1 J/cm²

*These cubes may be mounted on the Prism Tables shown on pages 394-395*

## *Broadband Polarizing Beamsplitter Cubes*






These cemented Polarizing Beamsplitter Cubes are coated to enable operation over a wide range of wavelengths.

The polarization separation is excellent with the transmitted and reflected beams at 90° to each other irrespective of wavelength.

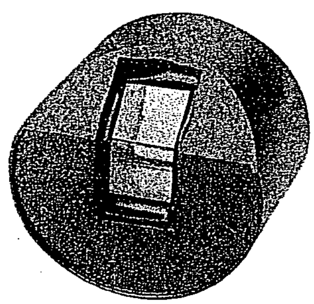
**Specifications**

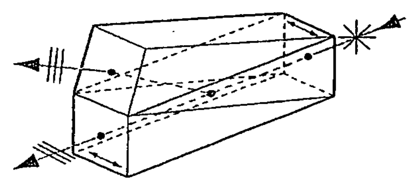
**Material:** SF-2 glass
**Transmission (p-polarized):** >90% average
**Reflection (s-polarized):** >99.8% average
**AR coating:** R <0.5% per surface, 400-700 nm
**Transmitted wavefront:** $\lambda/4$ at 633 nm
**Surface quality:** 20-10
**Extinction ratio:** >500:1
**Dimensions:** ±0.2 mm
**Clear aperture:** 85% of cube dimension
**Laser damage threshold**
CW: 2 kW/cm$^2$
Pulsed (10 ns): 1 J/cm$^2$

**Broadband Polarizing Beamsplitter Cubes**

| Wavelength Range (nm) | 12.7 mm Cube Catalog Number | 25.4 mm Cube Catalog Number |
|---|---|---|
| 450-700 | 44-4703 | 44-4711 |
| 670-980 | 44-4729 | 44-4737 |
| 1300-1550 | 44-4745 | 44-4752 |

## *Glan Thompson Beamsplitting Prisms*





Unlike standard Glan Thompson Polarizers (page 222-223), where the s-polarized ordinary ray is reflected and absorbed, these Beamsplitting Prisms have an additional escape window to allow transmission of the ordinary ray. The escape window is designed such that the beam emerges normal to it ensuring that there is no chromatic dispersion. The p-polarized extraordinary ray is transmitted undeviated from its original path. Coherent Glan Thompson Beamsplitting Prisms have an angular deviation between the two beams of 44° which is not wavelength dependent.

The main applications for these prisms are where there is a need for either a high extinction ratio, a large beam separation or wavelength independence. They are also useful where it is essential that the extraordinary ray is transmitted undeviated. These prisms are not suitable for high power applications. They are supplied mounted.

**Specifications**

**Material:** Optical calcite
**Wavelength Range:** 350-2500 nm
**Peak Transmission:** 90%
**Extinction Ratio:** $10^5$
**Surface Quality:** 20-10
**Beam Deviation:** <3 mins
**Dimensions:** ±0.1 mm
**Laser Damage Threshold:** 1 W/cm$^2$

**Glan Thompson Beamsplitting Prisms**

| Catalog Number | Aperture (mm) | Diameter (mm) | Length (mm) |
|---|---|---|---|
| 43-8515 | 7.0 | 25.4 | 36 |
| 43-8523 | 10.0 | 31.8 | 48 |
| 43-8531 | 12.0 | 38.1 | 49 |

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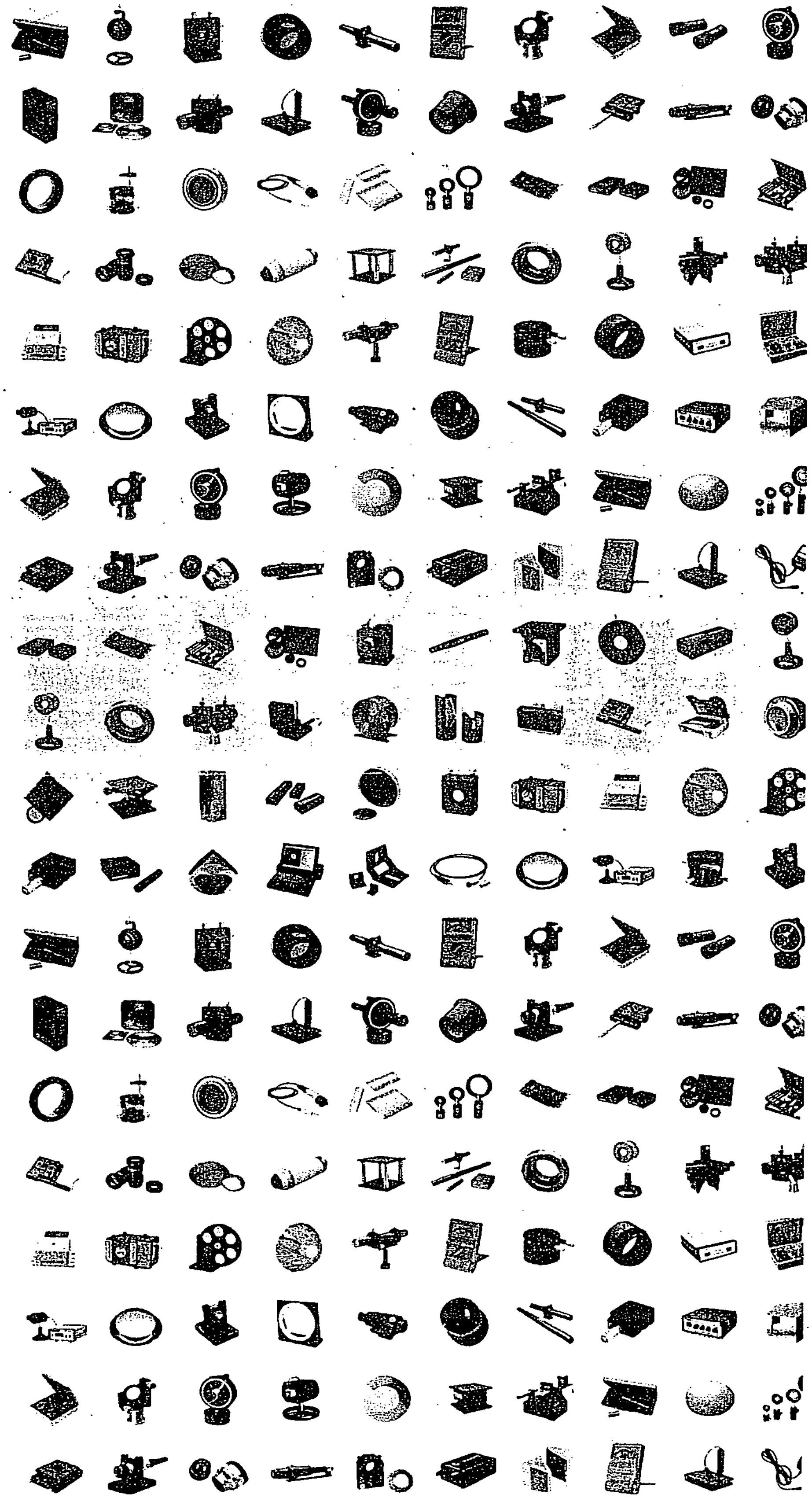
Toll Free: 0800 515801
Tel: +44 (0) 1923 242261
Fax: +44 (0) 1923 234220

**Germany**
Dieselstrasse 5b
D-64807 Dieburg
Germany
Tel: +49-6071-968-302
Fax: +49-6071-968-499

**France**
Domaine Technologique de Saclay
Bâtiment AZUR
4, rue René Razel
91892 Orsay Cedex
France
Tel: +33-1-60 19 40 40
Fax: +33-1-60 19 40 00

**Japan**
Toyo MK Building
7-2-14 Toyo
Koto-ku
Tokyo 135
Japan
Tel: +81 (0) 3 5635 8680
Fax: +81 (0) 3 5635 8681



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